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(54) **ESTIMATING A MILEAGE OF A VEHICLE**

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G08G 1/04	(2006.01)
G07B 15/02	(2011.01)
G07B 15/06	(2011.01)

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CPC ***G08G 1/0129*** (2013.01); ***G01C 22/00*** (2013.01); ***G05D 1/0253*** (2013.01); ***G08G 1/0116*** (2013.01); ***G08G 1/0175*** (2013.01); ***G08G 1/04*** (2013.01); *G05D 2201/0213* (2013.01); *G07B 15/02* (2013.01); *G07B 15/06* (2013.01); *G07B 15/063* (2013.01)

(58) **Field of Classification Search**

CPC G08G 1/0129; G08G 1/0116; G08G 1/04; G08G 1/0175; G05D 1/0253; G05D 2201/0213; G01C 22/00; G07B 15/063; G07B 15/06; G07B 15/02

See application file for complete search history.

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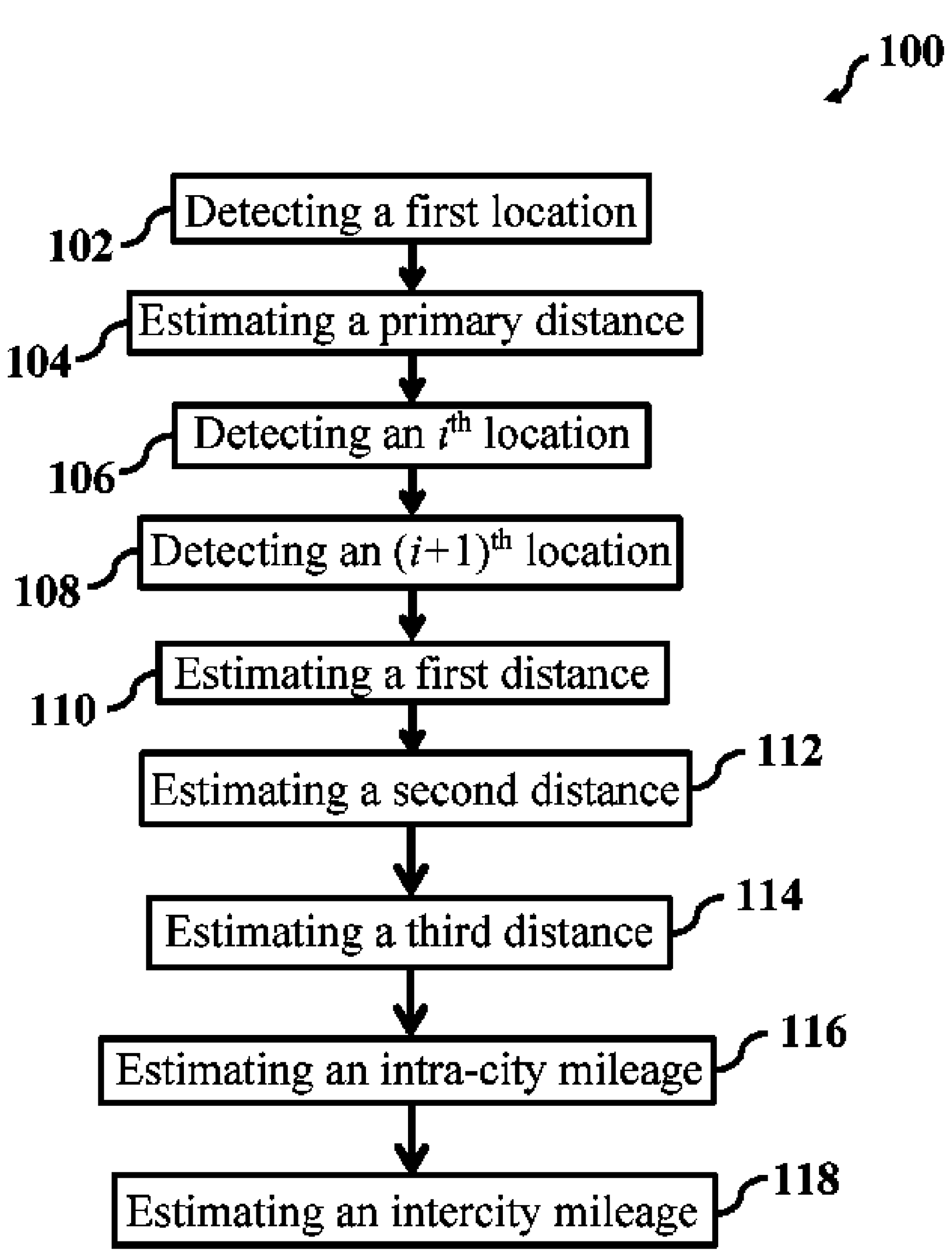
(57) **ABSTRACT**

A method for estimating a mileage of a vehicle is disclosed. The method includes detecting a first location of the vehicle at a first moment by capturing an image of the vehicle by a first camera of a plurality of cameras, and estimating a primary distance of a plurality of distances. The primary distance may be associated with the first location.

18 Claims, 3 Drawing Sheets



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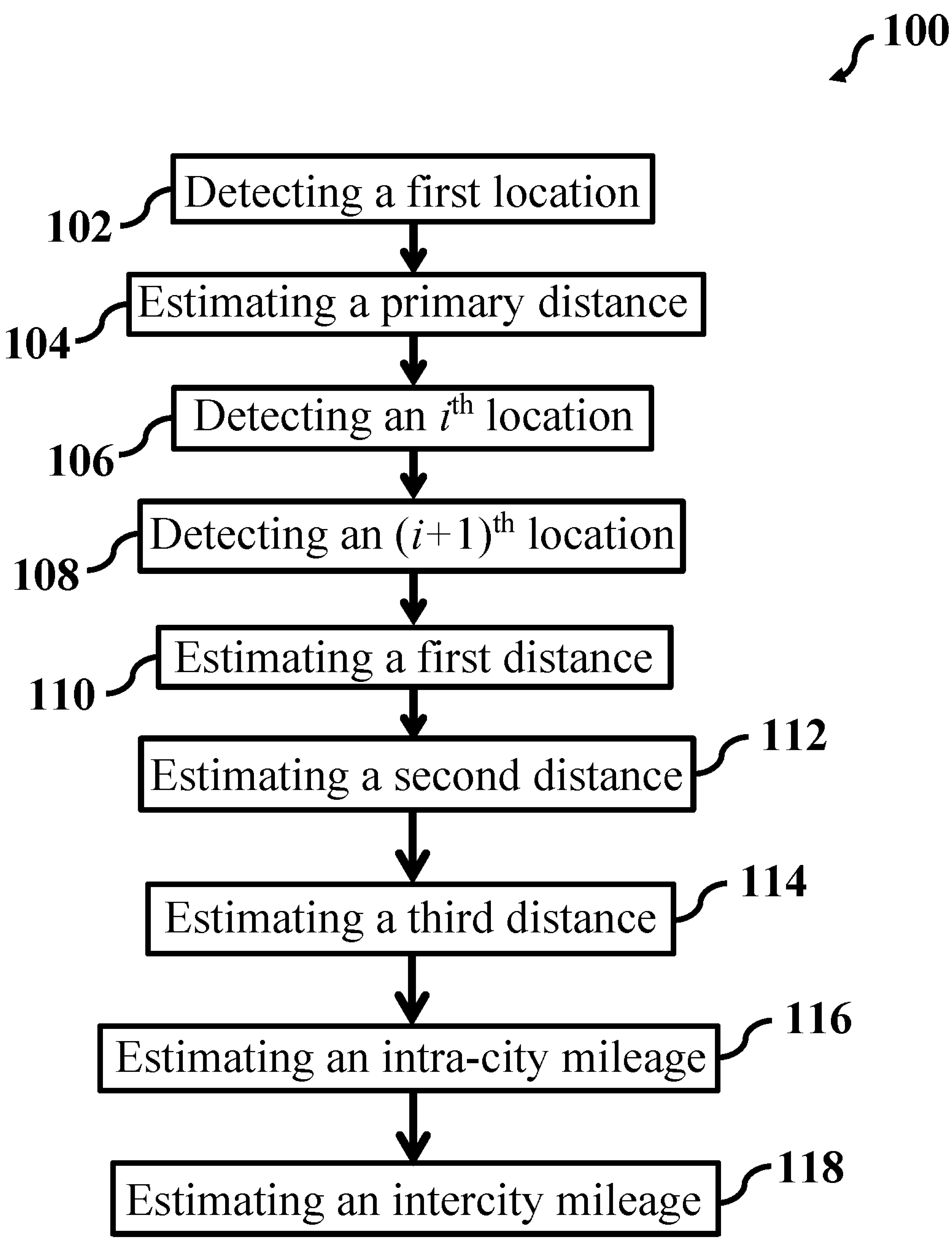
100
102
Detecting a first location
104
Estimating a primary distance
106
Detecting an i^{th} location
108
Detecting an $(i+1)^{th}$ location
110
Estimating a first distance
112
Estimating a second distance
114
Estimating a third distance
116
Estimating an intra-city mileage
118
Estimating an intercity mileage

FIG. 1

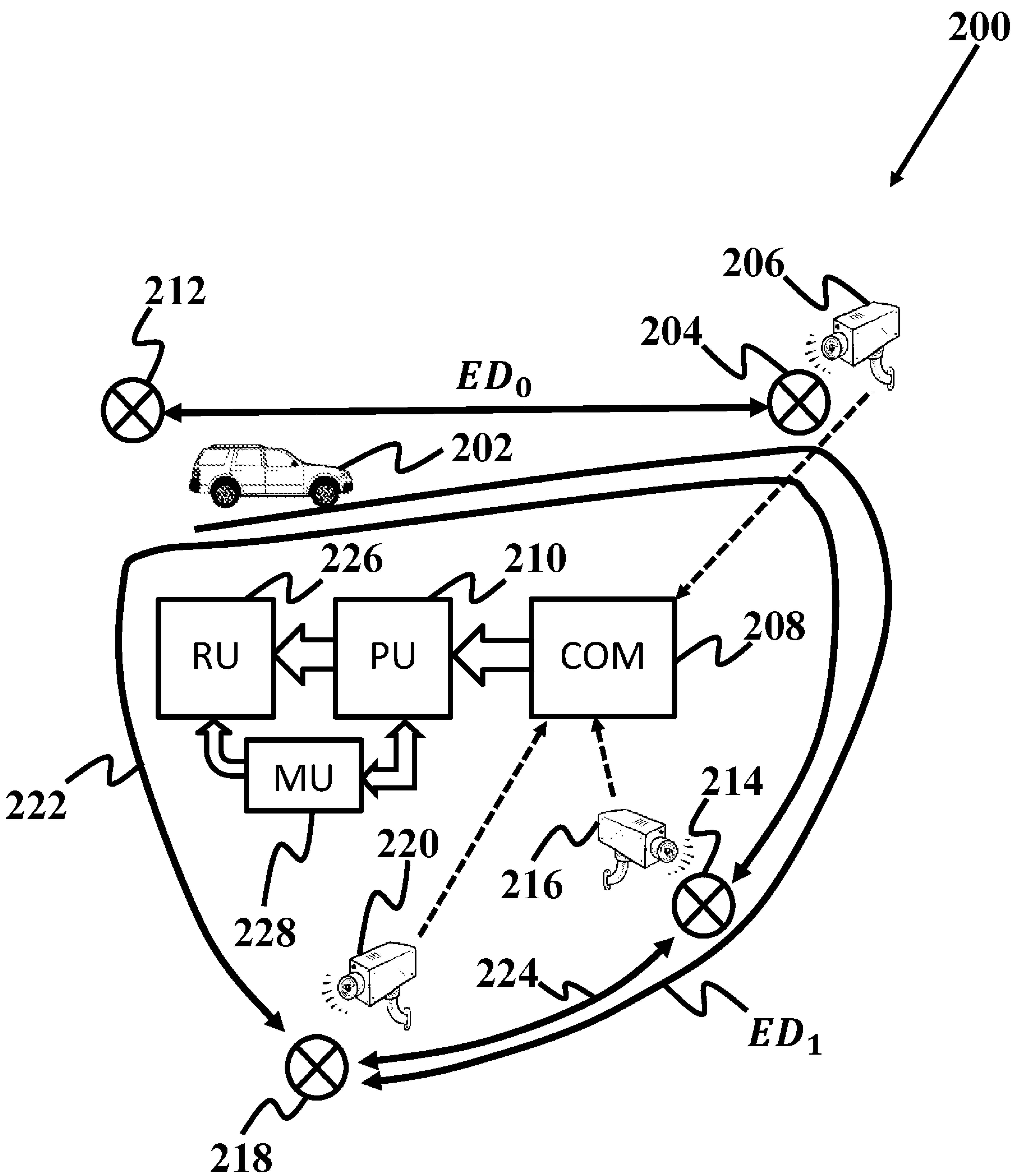
200
206
212
204
ED_0
202
226
210
RU
PU
COM
208
MU
222
214
220
216
228
224
ED_1
218

FIG. 2

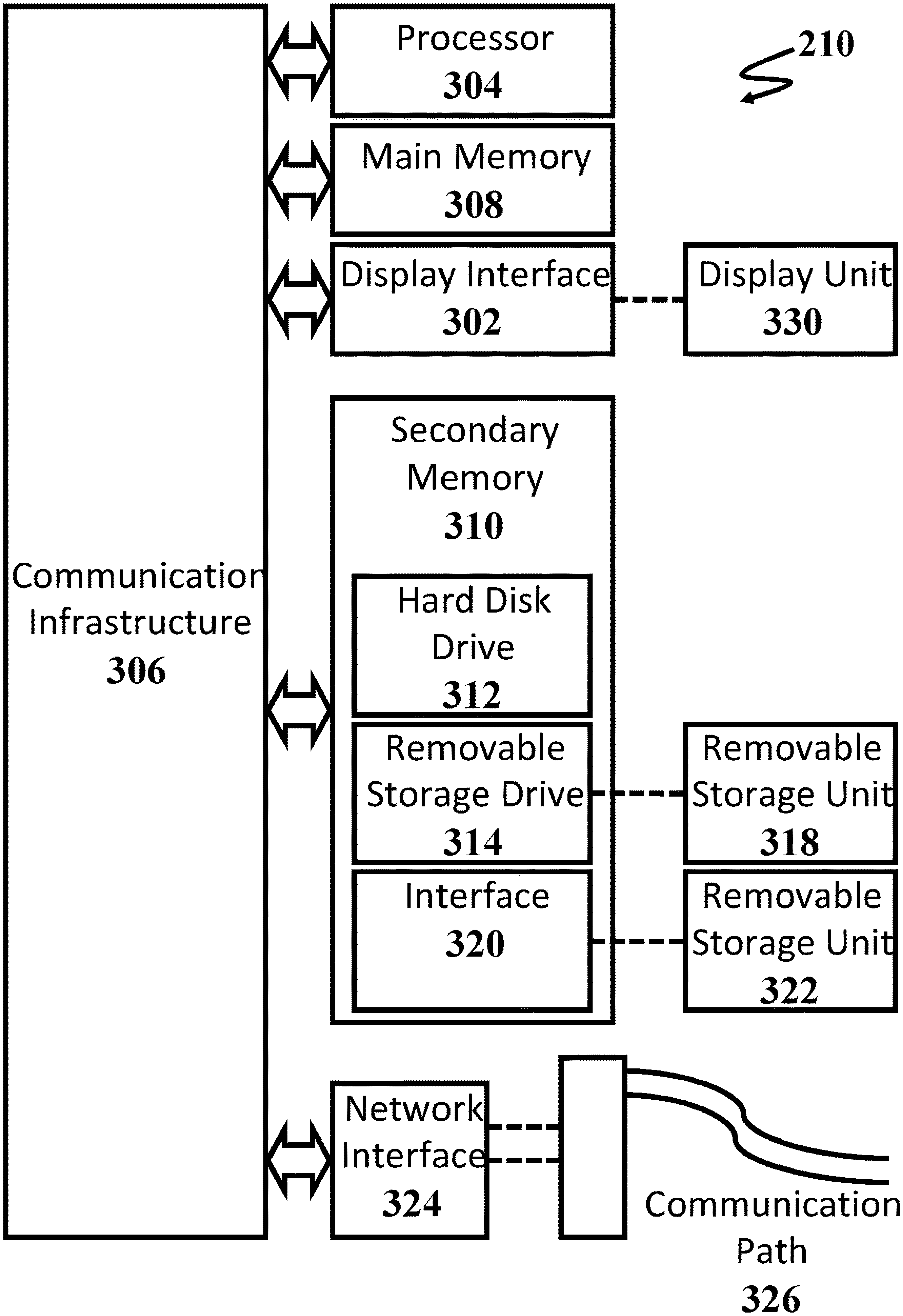
210
Processor
304
Main Memory
308
Display Interface
302
Display Unit
330
Communication
Infrastructure
306
Secondary
Memory
310
Hard Disk
Drive
312
Removable
Storage Drive
314
Removable
Storage Unit
318
Interface
320
Removable
Storage Unit
322
Network
Interface
324
Communication
Path
326

FIG. 3

ESTIMATING A MILEAGE OF A VEHICLE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority from U.S. Provisional Patent Application Ser. No. 62/553,925, filed on Sep. 4, 2017, and entitled "A SYSTEM AND METHOD FOR MONITORING VEHICLE HISTORY," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure generally relates to vehicles, and particularly, to vehicle traffic monitoring.

BACKGROUND

Vehicle mileage may be a useful parameter for vehicle assessment. Based on vehicle mileage, the quality of different elements of a vehicle may be assessed, and possible damage to the vehicle may be avoided.

A common method for measuring vehicle mileage is by using the vehicle odometer, which is installed in most vehicles by vehicle manufacturers. Other client-based methods also exist which require the clients to install measurement tools on the vehicle. However, most odometers and other measurement tools may be manually altered (for example, by the owner or the driver of the vehicle) to show incorrect values for vehicle mileage. There is, therefore, a need for a method that estimates vehicle mileage without being influenced by internal vehicle systems.

SUMMARY

This summary is intended to provide an overview of the subject matter of the present disclosure, and is not intended to identify essential elements or key elements of the subject matter, nor is it intended to be used to determine the scope of the claimed implementations. The proper scope of the present disclosure may be ascertained from the claims set forth below in view of the detailed description below and the drawings.

In one general embodiment, the present disclosure describes a method for estimating a mileage of a vehicle. The method includes detecting a first location of the vehicle at a first moment by capturing an image of the vehicle by a first camera of a plurality of cameras, and estimating a primary distance of a plurality of distances. The primary distance may be associated with the first location.

In an exemplary embodiment, estimating the primary distance may include calculating the primary distance according to an operation defined by $ED_0=2\times d_0$, where d_0 is a length of a route between a predefined place and the first location, and ED_0 is the primary distance. In an embodiment, capturing an image of the vehicle by the first camera may include capturing the image of the vehicle by a license plate recognition (LPR) camera.

In an exemplary embodiment, an exemplary method may further include detecting an i^{th} location of the vehicle at an i^{th} moment by capturing an image of the vehicle by an i^{th} camera of the plurality of cameras, where $2\leq i\leq N_c$ is an integer number and N_c is the number of the plurality of cameras, detecting an $(i+1)^{th}$ location of the vehicle at an $(i+1)^{th}$ moment by capturing an image of the vehicle by an $(i+1)^{th}$ camera of the plurality of cameras, and estimating a first distance of the plurality of distances according to an

operation defined by $ED_1=\Sigma_{i=1}^{N_c} d_i+ED_0$, where d_i is a length of a route between the i^{th} location and the $(i+1)^{th}$ location, and ED_1 is the first distance. In an embodiment, the i^{th} moment and the $(i+1)^{th}$ moment may satisfy a condition according to $t_{i+1}-t_i<t_0$, where t_0 is a temporal threshold, t_i is the i^{th} moment, and t_{i+1} is the $(i+1)^{th}$ moment.

In an exemplary embodiment, estimating the first distance may include selecting the route between the i^{th} location and the $(i+1)^{th}$ location from a longest path of a plurality of paths, a shortest path of the plurality of paths, and an average of the plurality of paths. Each of the plurality of paths may include a plurality of roads between the i^{th} location and the $(i+1)^{th}$ location.

In an exemplary embodiment, an exemplary method may further include estimating a second distance of the plurality of distances according to an operation defined by $ED_2=(N_c-1)d_{ave}+k$, where d_{ave} is an average distance associated with the plurality of cameras, k is a constant, and ED_2 is the second distance.

In an exemplary embodiment, an exemplary method may further include estimating a third distance of the plurality of distances according to an operation defined by $ED_3=ED_{ave}\ \Sigma_{m=1}^{M} T$, where ED_{ave} is an average distance associated with the plurality of distances, T is a given period of time, M is an integer constant associated with the given period of time, $1\leq m\leq M$ is an integer number, and ED_3 is the third distance.

In an exemplary embodiment, an exemplary method may further include estimating an intra-city mileage of the vehicle according to an operation defined by $ED_{city}=f_{city}(\Sigma_{m_1=1}^{M_1} ED_1, \Sigma_{m_2=1}^{M_2} ED_2, ED_3)$, where f_{city} is a function of the plurality of distances, M_1 and M_2 are integer constants, $1\leq m_1\leq M_1$ and $1\leq m_2\leq M_2$ are integer numbers, and ED_{city} is the intra-city mileage.

In an exemplary embodiment, an exemplary method may further include estimating an intercity mileage of the vehicle according to an operation defined by $ED_{inter}=f_{inter}(\Sigma_{m_1=1}^{M_1} ED_1, \Sigma_{m_2=1}^{M_2} ED_2, ED_3)$, where f_{inter} is a function of the plurality of distances, and ED_{inter} is the intercity mileage.

In an exemplary embodiment, an exemplary method for estimating a mileage of a vehicle is disclosed. The exemplary method includes detecting an i^{th} location of the vehicle by capturing an image of the vehicle by an i^{th} camera of a plurality of urban cameras where $1\leq i\leq N_1$ is an integer number and N_1 is the number of the plurality of urban cameras, detecting an $(i+1)^{th}$ location of the vehicle by capturing an image of the vehicle by an $(i+1)^{th}$ camera of the plurality of urban cameras, estimating a first urban distance of a plurality of urban distances according to the i^{th} location and the $(i+1)^{th}$ location, estimating a second urban distance of the plurality of urban distances, estimating a third urban distance of the plurality of urban distances, estimating an intra-city mileage of the vehicle according to the plurality of urban distances, detecting a j^{th} location of the vehicle by capturing an image of the vehicle by a j^{th} camera of a plurality of intercity cameras, where $1\leq j\leq N_2$ is an integer number and N_2 is the number of the plurality of intercity cameras, detecting a $(j+1)^{th}$ location of the vehicle by capturing an image of the vehicle by a $(j+1)^{th}$ camera of the plurality of intercity cameras, estimating a first intercity distance of a plurality of intercity distances according to the j^{th} location and the $(j+1)^{th}$ location, estimating a second intercity distance of the plurality of intercity distances, estimating a third intercity distance of the plurality of intercity distances, estimating an intercity mileage of the vehicle according to the plurality of intercity distances, estimating a total distance according to the intra-city mileage and the intercity mileage, and estimating an odometer

mileage variable of the vehicle according to the total distance. In an exemplary embodiment, each of the plurality of urban cameras may be installed on an urban road, and each of the plurality of intercity cameras may be installed on an intercity road.

In an exemplary embodiment, an exemplary system for estimating a mileage of a vehicle is disclosed. The exemplary system may include a first camera of a plurality of cameras, and a processor. In an embodiment, the first camera may be configured to capture a first image of the vehicle. In an exemplary embodiment, the processor may be configured to receive the first image of the vehicle, detect a first location of the vehicle at a first moment based on the first image of the vehicle, and estimate a primary distance of a plurality of distances. The first location may be associated with the first camera, and the primary distance may be associated with the first location.

Other exemplary systems, methods, features and advantages of the implementations will be, or will become, apparent to one of ordinary skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description and this summary, be within the scope of the implementations, and be protected by the claims herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing figures depict one or more implementations in accord with the present teachings, by way of example only, not by way of limitation. In the figures, like reference numerals refer to the same or similar elements.

FIG. **1** shows a flowchart of an exemplary embodiment of a method for estimating a mileage of a vehicle, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **2** shows a schematic of an exemplary embodiment of a system for estimating the mileage of a vehicle, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **3** shows an exemplary embodiment of a processing unit, consistent with one or more exemplary embodiments of the present disclosure.

DETAILED DESCRIPTION

In the following detailed description, numerous specific details are set forth by way of examples in order to provide a thorough understanding of the relevant teachings. However, it should be apparent that the present teachings may be practiced without such details. In other instances, well known methods, procedures, components, and/or circuitry have been described at a relatively high-level, without detail, in order to avoid unnecessarily obscuring aspects of the present teachings.

The following detailed description is presented to enable a person skilled in the art to make and use the methods and devices disclosed in exemplary embodiments of the present disclosure. For purposes of explanation, specific nomenclature is set forth to provide a thorough understanding of the present disclosure. However, it will be apparent to one skilled in the art that these specific details are not required to practice the disclosed exemplary embodiments. Descriptions of specific exemplary embodiments are provided only as representative examples. Various modifications to the exemplary implementations will be readily apparent to one skilled in the art, and the general principles defined herein may be applied to other implementations and applications without departing from the scope of the present disclosure. The present disclosure is not intended to be limited to the implementations shown, but is to be accorded the widest possible scope consistent with the principles and features disclosed herein.

Herein is disclosed an exemplary method and an exemplary system for estimating a mileage of a vehicle. The exemplary method estimates the mileage (or distance traveled by the vehicle, hereinafter may also be referred to as distance) based on a series of locations of the vehicle that may be extracted from a number of images of the vehicle taken by a number of cameras. Based on possible routes that may be passed by the vehicle between the detected locations, an estimation of the vehicle mileage may be obtained.

FIG. **1** shows a flowchart of an exemplary embodiment of a method **100** for estimating a mileage of a vehicle, consistent with one or more exemplary embodiments of the present disclosure. FIG. **2** shows a schematic of an exemplary embodiment of a system **200** for estimating the mileage of a vehicle **202**, consistent with one or more exemplary embodiments of the present disclosure. Referring to FIGS. **1** and **2**, method **100** may include detecting a first location **204** of vehicle **202** at a first moment t_1 by capturing an image of vehicle **202** by a first camera **206** of a plurality of cameras (step **102**), and estimating a primary distance ED_0 of a plurality of distances (step **104**). Primary distance ED_0 may be associated with first location **204**. In an embodiment, system **200** may include first camera **206**, a communication interface **208**, and a processing unit **210**. In an embodiment, first camera **206** may capture or obtain a first image of vehicle **202**, and communication interface **208** may communicate with the plurality of cameras. In an exemplary embodiment, communication interface **208** may include a wireless network, a local area network, a global network (such as the internet), or a communication satellite. In an exemplary embodiment, communication interface **208** may be integrated in a data center, or may be distributed among the plurality of cameras, or may include a combination of both integrated and distributed interfaces. For example, each camera may communicate with a separate communication interface, and each of the separate communication interfaces may communicate with other communication interfaces, or with a central communication interface. In an exemplary embodiment, processing unit **210** may detect first location **204** of vehicle **202** at first moment t_1 by importing the first image of vehicle **202** via communication interface **208** (step **102**), and estimate primary distance ED_0 (step **104**).

In an exemplary embodiment, step **104** may include calculating primary distance ED_0. Primary distance ED_0 may be calculated by processing unit **210** according to an operation defined by:

$$ED_0=2\times d_0, \qquad \text{Equation (1)}$$

where d_0 is a length of a route between a predefined place **212**, for example, a place of residence of an owner of vehicle **202**, and first location **204**. In an embodiment, first camera **206** may include a license plate recognition (LPR) camera. In an exemplary embodiment, Equation (1) may be used to obtain an approximation of a distance traveled by vehicle **202** in a case that a single location of vehicle **202** is detected in a sufficiently long period of time, so that it may be assumed that vehicle **202** has reached a destination. If no other location is detected, it may be assumed that vehicle **202** may have returned to its original location, for example, the predefined place **212**.

In an exemplary embodiment, method **100** may further include detecting an i^{th} location **214** of vehicle **202** at an i^{th} moment by capturing an image of vehicle **202** by an i^{th} camera **216** of the plurality of cameras (step **106**), where $2 \le i \le N_c$ is an integer number and N_c is the number of the plurality of cameras, detecting an $(i+1)^{th}$ location **218** of vehicle **202** at an $(i+1)^{th}$ moment by capturing an image of vehicle **202** by an $(i+1)^{th}$ camera **220** of the plurality of cameras (step **108**), and estimating a first distance ED_1 of the plurality of distances (step **110**). Images of vehicle **202** may be imported to processing unit **210** via communication interface **208** to detect i^{th} location **214** and $(i+1)^{th}$ location **218**. In an embodiment, first distance ED_1 may be calculated according to an operation defined by:

$$ED_1=\Sigma_{i=1}^{N_c} d_i + ED_0, \quad \text{Equation (2a)}$$

where d_i is a length of a route between i^{th} location **214** and $(i+1)^{th}$ location **218**, and may be set based on a weighted or statistical average distance between successive cameras of the plurality of cameras. In an embodiment, the i^{th} moment and the $(i+1)^{th}$ moment may satisfy a condition according to:

$$t_{i+1}-t_i<t_0,$$

where t_0 is a temporal threshold, t_i is the i^{th} moment, and t_{i+1} is the $(i+1)^{th}$ moment. In an embodiment, temporal threshold t_0 may be determined based on primary distance ED_0, or length d_i, or any of the plurality of distances. For short distances (such as urban distances), it may be assumed that vehicle **202** may pass successive cameras in a small period of time, and therefore a small value may be selected for temporal threshold t_0 for such cases. For longer distances (such as intercity distances), it may be assumed that vehicle **202** may pass successive cameras in a larger period of time, and therefore a larger value may be selected for temporal threshold t_0 for such cases.

In an exemplary embodiment, the plurality of cameras may include a plurality of urban cameras. Each of the plurality of urban cameras may be installed on an urban road. Therefore, estimating first distance ED_1 (step **110**) may include estimating a first urban distance $ED_{1,u}$ according to an operation defined by:

$$ED_{1,u}=\Sigma_{i=1}^{N_1} d_{i,u}, \quad \text{Equation (2b)}$$

where $d_{i,u}$ is a length of a route between i^{th} location **214** and $(i+1)^{th}$ location **218**, and N_1 is the number of the plurality of urban cameras.

In an exemplary embodiment, the plurality of cameras may include a plurality of intercity cameras. Each of the plurality of intercity cameras may be installed on an intercity road. Therefore, estimating first distance ED_1 (step **110**) may include estimating a first intercity distance according to an operation defined by:

$$ED_{1,r}=\Sigma_{i=1}^{N_2} d_{i,r}, \quad \text{Equation (2c)}$$

where $d_{j,r}$ is a length of a route between i^{th} location **214** and $(i+1)^{th}$ location **218**, N_2 is the number of the plurality of intercity cameras, and $ED_{1,r}$ is the first intercity distance.

In an exemplary embodiment, estimating first distance ED_1 (step **110**) may include selecting the route between i^{th} location **214** and $(i+1)^{th}$ location **218** from a longest path **222** of a plurality of paths, a shortest path **224** of the plurality of paths, and an average of the plurality of paths. Each of the plurality of paths may include a plurality of roads between i^{th} location **214** and $(i+1)^{th}$ location **218**.

In an exemplary embodiment, method **100** may further include estimating a second distance ED_2 of the plurality of distances (step **112**). Second distance ED_2 may be calculated by processing unit **210** according to an operation defined by:

$$ED_2=(N_c-1)d_{ave}+k, \quad \text{Equation (3a)}$$

where d_{ave} is an average distance associated with the plurality of cameras, and k is a constant. In an exemplary embodiment, average distance d_{ave} may be set based on a weighted or statistical average distance between successive cameras of the plurality of cameras, and constant k may be determined based on a distance between predefined place **212** and a known place in a neighborhood of predefined place **212** (such as the location of first camera **206**).

In an exemplary embodiment, second distance ED_2 may include a second urban distance $ED_{2,u}$. Based on Equation (3a), second urban distance $ED_{2,u}$ may be estimated according to an operation defined by:

$$ED_{2,u}=(N_1-1)d_{u\_ave}+k_u, \quad \text{Equation (3b)}$$

where d_{u_ave} is an average distance associated with the plurality of urban cameras, and k_u is a constant. In an exemplary embodiment, average distance d_{u_ave} may be set based on a weighted or statistical average distance between successive cameras of the plurality of urban cameras, and constant k_u may be determined based on a distance between predefined place **212** and a known place in a neighborhood of predefined place **212** (such as the location of first camera **206**).

In an exemplary embodiment, second distance ED_2 may include a second intercity distance $ED_{2,r}$. Based on Equation (3a), second intercity distance $ED_{2,r}$ may be estimated according to an operation defined by:

$$ED_{2,r}=(N_2-1)d_{r\_ave}+k_r, \quad \text{Equation (3c)}$$

where d_{r_ave} is an average distance associated with the plurality of intercity cameras, and k_r is a constant. In an exemplary embodiment, average distance d_{r_ave} may be set based on a weighted or statistical average distance between successive cameras of the plurality of intercity cameras, and constant k_r may be determined based on a distance between predefined place **212** and a known place in a neighborhood of predefined place **212** (such as the location of first camera **206**).

In an exemplary embodiment, method **100** may further include estimating a third distance ED_3 of the plurality of distances (step **114**). Third distance ED_3 may be calculated by processing unit **210** according to an operation defined by:

$$ED_3=ED_{ave}\Sigma_{m=1}^{M} T, \quad \text{Equation (4a)}$$

where ED_{ave} is an average distance associated with the plurality of distances, T is a given period of time, M is an integer constant associated with the given period of time, and $1 \le m \le M$ is an integer number. In an exemplary embodiment, period T may be a unit of time, for example, an hour, a day, a week, or a month, integer constant M may be number of periods that vehicle **202** may be used within a time limit (such as year), and ED_{ave} may be a weighted or statistical average of the plurality of distances based on a history of traveled distances by vehicle **202**.

In an exemplary embodiment, third distance ED_3 may include a third urban distance $ED_{3,u}$. Based on Equation (4a), third urban distance $ED_{3,u}$ may be estimated according to an operation defined by:

$$ED_{3,u}=ED_{u\_ave}\Sigma_{m=1}^{M_u} T_u, \quad \text{Equation (4b)}$$

where ED_{u_ave} is an average distance associated with the plurality of distances, T_u is a given period of time, and M_u is an integer constant associated with T_u. In an exemplary embodiment, period T_u may be a unit of time, for example, an hour, a day, a week, or a month, integer constant M_u may be number of periods that vehicle **202** may be used within a time limit (such as year), and ED_{u_ave} may be a weighted or statistical average of the plurality of urban distances based on a history of traveled distances by vehicle **202**.

In an exemplary embodiment, second distance ED_3 may include a third intercity distance $ED_{3,r}$. Based on Equation (4a), third intercity distance $ED_{3,r}$ may be estimated according to an operation defined by:

$$ED_{3,r}=ED_{r\_ave}\Sigma_{m=1}^{M_r}, \quad \text{Equation (4c)}$$

where ED_{r_ave} is an average distance associated with the plurality of intercity distances, T_r is a given period of time, and M_r is an integer constant associated with T_r. In an exemplary embodiment, period T_r may be a unit of time, for example, an hour, a day, a week, or a month, integer constant M_r may be number of periods that vehicle **202** may be used within a time limit (such as year), and ED_{r_ave} may be a weighted or statistical average of the plurality of intercity distances based on a history of traveled distances by vehicle **202**.

In an exemplary embodiment, method **100** may further include estimating an intra-city mileage ED_{city} of vehicle **202** (step **116**). Intra-city mileage ED_{city} may be estimated by processing unit **210** according to an operation defined by:

$$ED_{city}=f_{city}(\Sigma_{m_1=1}^{M_{u1}}ED_{1,u},\Sigma_{m_2=1}^{M_{u2}}ED_{2,u},ED_{3,u}), \quad \text{Equation (5)}$$

where f_{city} is a function of the plurality of distances, M_{u1} and M_{u2} are integer constants, and $1 \le m_1 \le M_{u1}$ and $1 \le m_2 \le M_{u2}$ are integer numbers. In an embodiment, integer constants M_{u1} and M_{u2} may be number of periods that vehicle **202** may be used within a time limit (such as year).

In an exemplary embodiment, method **100** may further include estimating an intercity mileage ED_{inter} of vehicle **202** (step **118**). Intercity mileage ED_{inter} may be estimated by computer system **210** according to an operation defined by:

$$ED_{inter}=f_{inter}(\Sigma_{m_1=1}^{M_{r1}}ED_{1,r},\Sigma_{m_2=1}^{M_{r2}}ED_{2,r},ED_{3,r}), \quad \text{Equation (6)}$$

where f_{inter} is a function of the plurality of distances, M_{r1} and M_{r2} are integer constants, and $1 \le m_1 \le M_{r1}$ and $1 \le m_2 \le M_{r2}$ are integer numbers. In an embodiment, integer constants M_{r1} and M_{r2} may be number of periods that vehicle **202** may be used within a time limit (such as year).

In an exemplary embodiment, method **100** may further include estimating a total distance ED_{total} according to an operation defined by:

$$ED_{total}=B_1 \times ED_{inter}+B_2 \times ED_{city}+B_3 \times H, \quad \text{Equation (7)}$$

where B_1, B_2, and B_3 are weighting parameters, and H is a constant. In a case that only an intercity mileage is required, weighting parameter B_1 may be set to 1, and B_2 and B_3 may be set to zero. In a case that only an intra-city mileage is required, weighting parameter B_2 may be set to 1, and B_1 and B_3 may be set to zero. In an embodiment, estimating total distance ED_{total} may include calculating constant H according to an operation defined by:

$$H=L_{min} \times N_{day}, \quad \text{Equation (8)}$$

where L_{min} is an estimate for a daily mileage of vehicle **202**, and N_{day} is a number of days associated with vehicle **202**. In an embodiment, N_{day} may be determined based on a number of days that vehicle **202** is intended to travel.

In an exemplary embodiment, method **100** may further include estimating an odometer mileage variable of vehicle **202** according to an operation defined by:

$$ED_{od}=ED_{total}+P+I, \quad \text{Equation (9)}$$

where P is an initial value for the odometer mileage variable, I is a correction constant, and ED_{od} is the odometer mileage variable. In an exemplary embodiment, initial value P may be set according to the odometer reading prior to starting method **100**. In an embodiment, correction constant I may be used if there is a need for possible corrections. For example, in some cases, an estimated value may be far from a reasonable estimate due to various types of error, such as system errors. In such cases, it may be possible to correct the estimated value by using correction constant I. By estimating the odometer mileage variable, possible odometer frauds may be prevented.

In an exemplary embodiment, processing unit **210** may compare the estimated mileage of vehicle **202** with a threshold, and in a case that the estimated mileage exceeds the threshold, processing unit **210** may send an alert to the owner of vehicle **202** via a facility such as a text message, a phone call, or an e-mail. The owner may be motivated by the alert to examine different parts of vehicle **202** and replace deteriorated parts with new ones. Another alert may also be sent to related authorities for appropriate actions.

In an exemplary embodiment, system **200** may further include a reporting unit **226**. Reporting unit **226** may generate a report of processed data to be sent to related authorities. In an exemplary embodiment, reporting unit **226** may include a printer, a monitor, or a communication facility.

In an exemplary embodiment, system **200** may further include a memory unit **228**. Memory unit **228** may store processed data and may send the processed data to processing unit **210** in a case that further process is required. For example, when a mileage of vehicle **202** is estimated, the mileage may be stored in memory unit **228** and may be used for further estimation in a case that a new location of vehicle **202** is detected. The stored data may also be sent to reporting unit **226** if required.

FIG. **3** illustrates an exemplary embodiment of processing unit **210** in which an embodiment of the present disclosure, or portions thereof, may be implemented as computer-readable code, consistent with exemplary embodiments of the present disclosure. For example, method **100** may be implemented in processing unit **210** using hardware, software, firmware, tangible computer readable media having instructions stored thereon, or a combination thereof and may be implemented in one or more computer systems or other processing systems. Hardware, software, or any combination of such may embody any steps in FIG. **1**.

If programmable logic is used, such logic may execute on a commercially available processing platform or a special purpose device. One of ordinary skill in the art may appreciate that an embodiment of the disclosed subject matter can be practiced with various computer system configurations, including multi-core multiprocessor systems, minicomputers, mainframe computers, computers linked or clustered with distributed functions, as well as pervasive or miniature computers that may be embedded into virtually any device.

For instance, a computing device having at least one processor device and a memory may be used to implement the above-described embodiments. A processor device may be a single processor, a plurality of processors, or combinations thereof. Processor devices may have one or more processor "cores."

An embodiment of the present disclosure is described in terms of this example processing unit **210**. After reading this description, it will become apparent to a person skilled in the relevant art how to implement the present disclosure using other computer systems and/or computer architectures.

Although operations may be described as a sequential process, some of the operations may in fact be performed in parallel, concurrently, and/or in a distributed environment, and with program code stored locally or remotely for access by single or multi-processor machines. In addition, in some embodiments the order of operations may be rearranged without departing from the spirit of the disclosed subject matter.

Processor device **304** may be a special purpose or a general-purpose processor device. As will be appreciated by persons skilled in the relevant art, processor device **304** may also be a single processor in a multi-core/multiprocessor system, such system operating alone, or in a cluster of computing devices operating in a cluster or server farm. In an exemplary embodiment, processor device **304** may be connected to a communication infrastructure **306**, for example, a bus, message queue, network, or multi-core message-passing scheme.

In an exemplary embodiment, processing unit **210** may include a display interface **302**, for example a video connector, to transfer data to a display unit **330**, for example, a monitor. In an exemplary embodiment, processing unit **210** may also include a main memory **308**, for example, random access memory (RAM), and may also include a secondary memory **310**. In an exemplary embodiment, secondary memory **310** may include a hard disk drive **312**, and a removable storage drive **314**. In an exemplary embodiment, removable storage drive **314** may include a floppy disk drive, a magnetic tape drive, an optical disk drive, a flash memory, or the like. In addition, removable storage drive **314** may read from and/or write to a removable storage unit **318** in a well-known manner. In an exemplary embodiment, removable storage unit **318** may include a floppy disk, magnetic tape, optical disk, etc., which may be read by and written to by removable storage drive **314**. As will be appreciated by persons skilled in the relevant art, removable storage unit **318** may include a computer usable storage medium having stored therein computer software and/or data.

In alternative implementations, secondary memory **310** may include other similar means for allowing computer programs or other instructions to be loaded into processing unit **210**. Such means may include, for example, a removable storage unit **322** and an interface **320**. Examples of such means may include a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an EPROM, or PROM) and associated socket, and other removable storage units **322** and interfaces **320** which allow software and data to be transferred from removable storage unit **322** to processing unit **210**.

In an exemplary embodiment, processing unit **210** may also include a communications interface **324**. Communications interface **324** may allow software and data to be transferred between processing unit **210** and external devices. In an embodiment, communications interface **324** may include a modem, a network interface (such as an Ethernet card), a communications port, a PCMCIA slot and card, or the like. Software and data transferred via communications interface **324** may be in the form of signals, which may be electronic, electromagnetic, optical, or other signals capable of being received by communications interface **324**. These signals may be provided to communications interface **324** via a communications path **326**. In an exemplary embodiment, communications path **326** may carry signals and may be implemented using wire or cable, fiber optics, a phone line, a cellular phone link, an RF link or other communications channels.

In this document, the terms "computer program medium" and "computer usable medium" are used to generally refer to media such as removable storage unit **318**, removable storage unit **322**, and a hard disk installed in hard disk drive **312**. Computer program medium and computer usable medium may also refer to memories, such as main memory **308** and secondary memory **310**, which may be memory semiconductors (e.g. DRAMs, etc.).

In some exemplary embodiment, computer programs (also called computer control logic) may be stored in main memory **308** and/or secondary memory **310**. Computer programs may also be received via communications interface **324**. Such computer programs, when executed, enable processing unit **210** to implement the present disclosure as discussed herein. In particular, the computer programs, when executed, may enable processor device **304** to implement the processes of the present disclosure, such as the operations in method **100** discussed above. Accordingly, such computer programs represent controllers of processing unit **210**. Where the present disclosure is implemented using software, the software may be stored in a computer program product and loaded into processing unit **210** using removable storage drive **314**, interface **320**, and hard disk drive **312**, or communications interface **324**.

Embodiments of the present disclosure may also be directed to computer program products including software stored on any computer useable medium. Such software, when executed in one or more data processing devices, causes a data processing device(s) to operate as described herein. An embodiment of the present disclosure may employ any computer useable or readable medium. Examples of computer useable mediums include, but are not limited to, primary storage devices (e.g., any type of random access memory), secondary storage devices (e.g., hard drives, floppy disks, CD ROMS, ZIP disks, tapes, magnetic storage devices, and optical storage devices, MEMS, nanotechnological storage device, etc.).

Example

In this example, a mileage estimation of a car during an about 7 year period by using exemplary method **100** is presented. Table 1 shows the mileage M_o of the car according to the car odometer, the estimated mileage M_e, and the relative error RE of the estimates, given by

$$RE = \left|\frac{M_e - M_o}{M_o}\right|, \quad \text{Equation (10)}$$

TABLE 1

Odometer and estimated mileages of a car.

Date	Odometer mileage	The estimated mileage	Relative error (%)
2008 Apr. 3	0	—	—
2008 Apr. 5	20	—	—
2008 Apr. 20	30	28	6/67
2008 Apr. 21	45	40	11/1
2009 Apr. 18	15000	14500	3/33
2010 Apr. 4	30600	30000	1/96
2010 Apr. 14	31000	30200	2/58

TABLE 1-continued

Odometer and estimated mileages of a car.

Date	Odometer mileage	The estimated mileage	Relative error (%)
2011 Apr. 14	45000	43500	3/33
2011 Jun. 23	49000	47000	4/08
2011 Jun. 24	49100	47100	4/07
2011 Jun. 25	49200	47200	4/07
2014 Apr. 13	67000	64500	3/73
2014 Apr. 18	67050	64550	3/73
2013 Apr. 9	88500	85800	3/05
2013 Apr. 14	88700	85700	3/38
2013 Apr. 16	89000	86000	3/37
2014 Apr. 19	109500	106000	3/2
2014 Aug. 25	117000	113500	2/99
2014 Aug. 26	117050	113540	3
2014 Aug. 27	117070	113560	3
2015 Apr. 17	120000	116000	3/33

While the foregoing has described what may be considered to be the best mode and/or other examples, it is understood that various modifications may be made therein and that the subject matter disclosed herein may be implemented in various forms and examples, and that the teachings may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all applications, modifications and variations that fall within the true scope of the present teachings.

Unless otherwise stated, all measurements, values, ratings, positions, magnitudes, sizes, and other specifications that are set forth in this specification, including in the claims that follow, are approximate, not exact. They are intended to have a reasonable range that is consistent with the functions to which they relate and with what is customary in the art to which they pertain.

The scope of protection is limited solely by the claims that now follow. That scope is intended and should be interpreted to be as broad as is consistent with the ordinary meaning of the language that is used in the claims when interpreted in light of this specification and the prosecution history that follows and to encompass all structural and functional equivalents. Notwithstanding, none of the claims are intended to embrace subject matter that fails to satisfy the requirement of Sections 101, 102, or 103 of the Patent Act, nor should they be interpreted in such a way. Any unintended embracement of such subject matter is hereby disclaimed.

Except as stated immediately above, nothing that has been stated or illustrated is intended or should be interpreted to cause a dedication of any component, step, feature, object, benefit, advantage, or equivalent to the public, regardless of whether it is or is not recited in the claims.

It will be understood that the terms and expressions used herein have the ordinary meaning as is accorded to such terms and expressions with respect to their corresponding respective areas of inquiry and study except where specific meanings have otherwise been set forth herein. Relational terms such as first and second and the like may be used solely to distinguish one entity or action from another without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "a" or "an" does not, without further constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various implementations. This is for purposes of streamlining the disclosure, and is not to be interpreted as reflecting an intention that the claimed implementations require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed implementation. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

While various implementations have been described, the description is intended to be exemplary, rather than limiting and it will be apparent to those of ordinary skill in the art that many more implementations and implementations are possible that are within the scope of the implementations. Although many possible combinations of features are shown in the accompanying figures and discussed in this detailed description, many other combinations of the disclosed features are possible. Any feature of any implementation may be used in combination with or substituted for any other feature or element in any other implementation unless specifically restricted. Therefore, it will be understood that any of the features shown and/or discussed in the present disclosure may be implemented together in any suitable combination. Accordingly, the implementations are not to be restricted except in light of the attached claims and their equivalents. Also, various modifications and changes may be made within the scope of the attached claims.

What is claimed is:

1. A method for estimating a mileage of a vehicle, the method comprising:

detecting an i^{th} location of the vehicle by capturing an image of the vehicle by an i^{th} camera of a plurality of urban cameras, where $1 \le i \le N_1$ is an integer number and N_1 is the number of the plurality of urban cameras;

detecting an $(i+1)^{th}$ location of the vehicle by capturing an image of the vehicle by an $(i+1)^{th}$ camera of the plurality of urban cameras;

estimating a first urban distance of a plurality of urban distances according to an operation defined by:

$$ED_{1,u} = \sum_{i=1}^{N_1} d_{i,u},$$

where $d_{i,u}$ is a length of a route between the i^{th} location and the $(i+1)^{th}$ location, and $ED_{1,u}$ is the first urban distance;

estimating a second urban distance of the plurality of urban distances according to an operation defined by:

$$ED_{2,u}=(N_1-1)d_{u\_ave}+k_u,$$

where d_{u_ave} is an average distance associated with the plurality of urban cameras, k_u is a constant, and $ED_{2,u}$ is the second urban distance;

estimating a third urban distance of the plurality of urban distances according to an operation defined by:

$$ED_{3,u} = ED_{u\_ave}\sum_{m=1}^{M_u} T_u,$$

where ED_{u_ave} is an average distance associated with the plurality of distances, T_u is a given period of time, M_u is an integer constant associated with the given period of time, $1 \le m \le M_u$ is an integer number, and $ED_{3,u}$ is the third urban distance;

estimating an intra-city mileage of the vehicle according to an operation defined by:

$$ED_{city} = f_{city}\left(\sum_{m_1=1}^{M_{u1}} ED_{1,u}, \sum_{m_2=1}^{M_{u2}} ED_{2,u}, ED_{3,u}\right),$$

where f_{city} is a function of the plurality of urban distances, M_{u1} and M_{u2} are integer constants, $1 \le m_1 \le M_{u1}$ and $1 \le m_2 \le M_{u2}$ are integer numbers, and ED_{city} is the intra-city mileage;

detecting a j^{th} location of the vehicle by capturing an image of the vehicle by a j^{th} camera of a plurality of intercity cameras, where $1 \le j \le N_2$ is an integer number and N_2 is the number of the plurality of intercity cameras;

detecting a $(j+1)^{th}$ location of the vehicle by capturing an image of the vehicle by a $(j+1)^{th}$ camera of the plurality of intercity cameras;

estimating a first intercity distance of a plurality of intercity distances according to an operation defined by:

$$ED_{1,r} = \sum_{j=1}^{N_2} d_{j,r},$$

where $d_{j,r}$ is a length of a route between the j^{th} location and the $(j+1)^{th}$ location, and $ED_{1,r}$ is the first intercity distance;

estimating a second intercity distance of the plurality of intercity distances according to an operation defined by:

$$ED_{2,r} = (N_2 - 1)d_{r\_ave} + k_r,$$

where d_{r_ave} is an average distance associated with the plurality of intercity cameras, k_r is a constant, and $ED_{2,r}$ is the second intercity distance;

estimating a third intercity distance of the plurality of intercity distances according to an operation defined by:

$$ED_{3,r} = ED_{r\_ave}\sum_{m=1}^{M_r} T_r,$$

where ED_{r_ave} is an average distance associated with the plurality of intercity distances, T_r is a given period of time, M_r is an integer constant associated with the given period of time, $1 \le m \le M_r$ is an integer number, and $ED_{3,r}$ is the third intercity distance;

estimating an intercity mileage of the vehicle according to an operation defined by:

$$ED_{inter} = f_{inter}\left(\sum_{m_1=1}^{M_{r1}} ED_{1,r}, \sum_{m_2=1}^{M_{r2}} ED_{2,r}, ED_{3,r}\right),$$

where f_{inter} is a function of the plurality of intercity distances, M_{r1} and M_{r2} are integer constants, $1 \le m_1 \le M_{r1}$ and $1 \le m_2 \le M_{r2}$ are integer numbers, and ED_{inter} is the intercity mileage;

estimating a total distance according to an operation defined by:

$$ED_{total} = B_1 \times ED_{inter} + B_2 \times ED_{city} + B_3 \times H,$$

where B_1, B_2, and B_3 are weighting parameters, and H is a constant; and

estimating an odometer mileage variable of the vehicle according to an operation defined by:

$$ED_{od} = ED_{total} + P + I,$$

where P is an initial value for the odometer mileage variable, I is a correction constant, and ED_{od} is the odometer mileage variable.

2. The method of claim **1**, wherein estimating the total distance comprises calculating constant H according to an operation defined by:

$$H = L_{min} \times N_{day},$$

where L_{min} is an estimate for a daily mileage of the vehicle and N_{day} is a number of days associated with the vehicle.

3. A method for estimating a mileage of a vehicle, the method comprising:

detecting an i^{th} location of the vehicle at an i^{th} moment by capturing an image of the vehicle by an i^{th} camera of a plurality of cameras, where $1 < i < N_c$ is an integer number and N_c is the number of the plurality of cameras;

detecting an $(i+1)^{th}$ location of the vehicle at an $(i+1)^{th}$ moment by capturing an image of the vehicle by an $(i+1)^{th}$ camera of the plurality of cameras; and

estimating a first distance of a plurality of distances according to an operation defined by:

$$ED_1 = \Sigma_{i-1}^{N_c} d_i + ED_0,$$

where d_i is a length of a route between the i^{th} location and the $(i+1)^{th}$ location, ED_0 is a primary distance, and ED_1 is the first distance.

4. The method of claim **3**, further comprising estimating the primary distance according to an operation defined by:

$$ED_0 = 2 \times d_0,$$

where d_0 is a length of a route between a predefined place and a first location of the vehicle.

5. The method of claim **3**, wherein capturing the image of the vehicle by i^{th} camera comprises capturing the image of the vehicle by a license plate recognition (LPR) camera.

6. The method of claim **3**,

wherein the i^{th} moment and the $(i+1)^{th}$ moment satisfy a condition according to:

$t_{i+1} - t_i < t_0$, where t_0 is a temporal threshold, t_i is the i^{th} moment, and t_{i+1} is the $(i+1)^{th}$ moment.

7. The method of claim **6**, wherein estimating the first distance comprises selecting a route between the i^{th} location and the $(i+1)^{th}$ location from a longest path of a plurality of paths, a shortest path of the plurality of paths, and an average of the plurality of paths, each of the plurality of paths comprising a plurality of roads between the i^{th} location and the $(i+1)^{th}$ location.

8. The method of claim **6**, further comprising:

estimating a second distance of the plurality of distances according to an operation defined by:

$$ED_2=(N_c-1)d_{ave}+k,$$

where d_{ave} is an average distance associated with the plurality of cameras, k is a constant, and ED_2 is the second distance.

9. The method of claim **8**, further comprising:

estimating a third distance of the plurality of distances according to an operation defined by:

$$ED_3 = ED_{ave}\sum_{m=1}^{M} T,$$

where ED_{ave} is an average distance associated with the plurality of distances, T is a given period of time, M is an integer constant associated with the given period of time, $1 \le m \le M$ is an integer number, and ED_3 is the third distance.

10. The method of claim **9**, further comprising:

estimating an intra-city mileage of the vehicle according to an operation defined by:

$$ED_{city} = f_{city}\left(\sum_{m_1=1}^{M_1} ED_1, \sum_{m_2=1}^{M_2} ED_2, ED_3\right),$$

where f_{city} is a function of the plurality of distances, M_1 and M_2 are integer constants, $1 \le m_1 \le M_1$ and $1 \le m_2 \le M_2$ are integer numbers, and ED_{city} is the intra-city mileage.

11. The method of claim **9**, further comprising:

estimating an intercity mileage of the vehicle according to an operation defined by:

$$ED_{inter} = f_{inter}\left(\sum_{m_1=1}^{M_1} ED_1, \sum_{m_2=1}^{M_2} ED_2, ED_3\right),$$

where f_{inter} is a function of the plurality of distances, M_1 and M_2 are integer constants, $1 \le m_1 \le M_1$ and $1 \le m_2 \le M_2$ are integer numbers, and ED_{inter} is the intercity mileage.

12. A system for estimating a mileage of a vehicle, the system comprising:

an i^{th} camera of a plurality of cameras, where $1<i<N_c$ is an integer number and N_c is the number of the plurality of cameras, the i^{th} camera configured to capture an i^{th} image of the vehicle at an i^{th} moment;

an $(i+1)^{th}$ camera of the plurality of cameras, the $(i+1)^{th}$ camera configured to capture an $(i+1)^{th}$ image of the vehicle at an $(i+1)^{th}$ moment; and

a processor configured to:

receive the i^{th} image of the vehicle from the i^{th} camera;

detect and i^{th} location of the vehicle based on the i^{th} image of the vehicle;

receive the $(i+1)^{th}$ image of the vehicle from the $(i+1)^{th}$ camera;

detect an $(1+1)^{th}$ location of the vehicle based on the $(1+1)^{th}$ image of the vehicle; and

estimate a first distance of the plurality of distances according to an operation defined by:

$$ED_1=\Sigma_{i=1}^{N_c} d_i+ED_0,$$

where d_i is a length of a route between the i^{th} location and the $(i+1)^{th}$ location, ED_0 is a primary distance, and ED_1 is the first distance.

13. The system of claim **12**, wherein the processor is further configured to estimate the primary distance according to an operation defined by:

$$ED_0=2\times d_0,$$

where d_0 is a length of a route between a place of residence of an owner of the vehicle and a first location of the vehicle.

14. The system of claim **12**, wherein

the i^{th} moment and the $(i+1)^{th}$ moment satisfy a condition according to:

$t_{i+1}-t_i<t_0$, where t_0 is a temporal threshold, t_i is the i^{th} moment, and t_{i+1} is the $(i+1)^{th}$ moment.

15. The system of claim **14**, wherein the processor is further configured to estimate a second distance of the plurality of distances according to an operation defined by:

$$ED_2=(N_c-1)d_{ave}+k,$$

where d_{ave} is an average distance associated with the plurality of cameras, k is a constant, and ED_2 is the second distance.

16. The system of claim **15**, wherein the processor is further configured to estimate a third distance of the plurality of distances according to an operation defined by:

$$ED_3 = ED_{ave}\sum_{m=1}^{M} T,$$

where ED_{ave} is an average distance associated with the plurality of distances, T is a given period of time, M is an integer constant associated with the given period of time, $1 \le m \le M$ is an integer number, and ED_3 is the third distance.

17. The system of claim **16**, wherein the processor is further configured to estimate an intra-city mileage of the vehicle according to an operation defined by:

$$ED_{city} = f_{city}\left(\sum_{m_1=1}^{M_1} ED_1, \sum_{m_2=1}^{M_2} ED_2, ED_3\right),$$

where f_{city} is a function of the plurality of distances, M_1 and M_2 are integer constants, $1 \le m_1 \le M_1$ and $1 \le m_2 \le M_2$ are integer numbers, and ED_{city} is the intra-city mileage.

18. The system of claim **16**, wherein the processor is further configured to estimate an intercity mileage of the vehicle according to an operation defined by:

$$ED_{inter} = f_{inter}\left(\sum_{m_1=1}^{M_1} ED_1, \sum_{m_2=1}^{M_2} ED_2, ED_3\right),$$

where f_{inter} is a function of the plurality of distances, M_1 and M_2 are integer constants, $1 \leq m_1 \leq M_1$ and $1 \leq m_2 \leq M_2$ are integer numbers, and ED_{inter} is the intercity mileage.

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